Pelagic Fish (Delta Smelt and Longfin Smelt): Conservation Themes with Stressors, Impact Mechanisms, and Conservation Actions

Note: Information presented in this draft table is a preliminary work in progress and will continue to be refined based on new information as it is gathered. Citations and other documentation supporting the information will be provided in or appended to the table as more specific information is developed. This table was prepared by the following individuals at a BDCP technical working session held on March 12, 2007: Chuck Hanson (Hanson Environmental); Diane Wyndom and Rosalie del Rosario (NMFS); Jim White and Neil Clipperton (DFG); Bill Harrell (DWR); Bill Bennett (UC Davis); Rick Sitts, David Fullerton, and Pete Rhoads (Metropolitan); Ron Kino (Mirant); and Campbell Ingram (TNC); and Pete Rawlings (SAIC). Life stages that could be affected by a stressor are indicated by an "X" in the table and life stages that are not believed to be affected by a stressor are indicated by a "0".

Conservation Theme	Stressor	Impact Mechanism	Pelagic Fish				Potential Conservation Measures
			Egg	Larvae	Juvenile	Adult	
Theme 1. Reduce Sources Of Mortality							
1-1	State Water Project (SWP) entrainment	Loss through louvers	0	X	X	X	▪ Install fish screens[1] ▪ Improve louvers ▪ Real-time/seasonal operations ▪ Reduce reverse flows within Old and Middle Rivers ▪ Increase SJR inflows ▪ Increase outflow ▪ Relocate intake ▪ Prevent entry of smelt into Clifton Court Forebay [2](CCF)

[1] It is unclear that screening is an effective measure to minimize entrainment losses.
[2] When smelt enter into CCF they are lost—need to identify methods by which smelt can be isolated from CCF.

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Conservation Theme	Stressor	Impact Mechanism	Pelagic Fish				Potential Conservation Measures
			Egg	Larvae	Juvenile	Adult	
1-1b	Central Valley Project (CVP) entrainment	Entrainment into CCF	0	X	X	X	▪ Install fish screens ▪ Real-time/seasonal operations ▪ Reduce reverse flows within Old and Middle Rivers ▪ Increase outflow ▪ Relocate intake ▪ Prevent entry of smelt into CCF[2]
1-2	SWP/CVP salvage	Collection, Handling, Transportation, Release (CHTR) mortality[3]	0	X	X	X	▪ Install fish screens ▪ Improve louvers ▪ Improve CHTR process ▪ Seasonal operations ▪ Increase outflow ▪ Relocate intake
1-3	Clifton Court predation	Predation	0	?[4]	X	X	▪ Predator management/removal ▪ Modify Forebay ▪ Remove Forebay ▪ Install fish screens ▪ Relocate intake
1-4	DWR owned diversions (e.g., Sherman Is.)	Loss at unscreened diversions (check to confirm that unscreened diversions are not being used)	0	X	X	X	▪ Install fish screens ▪ Consolidate diversions ▪ Remove diversion ▪ Seasonal operations
1-5	USBR owned diversion	Loss at unscreened diversion	0	X	X	X	▪ Install fish screens ▪ Consolidate diversions ▪ Remove diversion ▪ Seasonal operations
1-6	Private diversions (CCWD, agricultural)	Entrainment loss/exposure to thermal discharge plume	0	X	X	X	▪ Install fish screens ▪ Consolidate diversions ▪ Remove diversion ▪ Seasonal operations ▪ Retire/replace power plant units equipped with off-stream cooling

[3] Directed primarily towards addressing post-release entrainment and predation mortality.
[4] Not enough is known to determine if life stage is affected.

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			Egg	Larvae	Juvenile	Adult	
1-6b	Mirant Pittsburg and Contra Costa power plants	Entrainment loss/exposure to thermal discharge plume	0	X	X	X	▪ Install fish screens ▪ Consolidate diversions ▪ Remove diversion ▪ Seasonal operations ▪ Retire/replace power plant units equipped with off-stream cooling
1-7	North Bay Aqueduct	Entrainment	0	X	X	X	▪ Install fish screens ▪ Remove diversion ▪ Seasonal operations ▪ Consolidate diversions
1-8	Exposure to toxics	Chronic and acute mortality	X	X	X	X	▪ Source control ▪ Point-source reduction ▪ Non-point source reduction ▪ Sediment removal/capping/avoid resuspension ▪ TMDL ▪ Increased enforcement ▪ Modify pesticide technology (shift to less toxic methods)
1-9	Predation[5]	Predation	?[6]	X	X	X	▪ Predator management/removal ▪ Increase cover habitat ▪ Reduce ambush points ▪ Avoid future introductions ▪ Modification of channel geometry (where hotspots for predation, e.g., split of old river)
1-10	Propeller entrainment[7]	Entrainment	0	?[4]	X	X	▪ Increase off-channel habitat ▪ Reduce vessel transit through Delta
1-11	Harvest	Incidental mortality and removal	0	0	0	0	▪ None[8]

[5] Focus is on conditions that create non-natural heightened vulnerability to predation.
[6] No data is available regarding egg predation.
[7] For example, cargo vessels can entrain and kill fish in propeller/propwash, pressure change can disorient fish, and wake disturbances can increase vulnerability to predation (e.g., Port of Stockton). This stressor also affects salmonids.
[8] This is not a stressor on smelt.

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Conservation Theme	Stressor	Impact Mechanism	Pelagic Fish				Potential Conservation Measures
			Egg	Larvae	Juvenile	Adult	
1-11b	Illegal harvest	Incidental mortality and removal	0	0	0	0	▪ None[8]
1-12	Insufficient food supplies/location	Reduced growth/health/starvation	0	X	X	X	▪ Conservation actions under Conservation Theme 6 apply
1-13	Disease	Direct mortality, increased susceptibility to predation	?[9]	?[8]	?[8]	?[8]	▪ None proposed at this time.
Theme 2. Increase Species Production (reproduction, growth, survival)							
2-1	Insufficient food supplies/location	Reduced growth/health/starvation	0	X	X	X	▪ Conservation actions under Conservation Theme 6 apply
2-2	Reduced suitable spawning habitat	Insufficient spawning conditions (e.g., substrate, temperature)	?[10]	0	0	?[9]	▪ Enhance spawning conditions(availability and/or quality)[11]
2-3	Reduced suitable rearing habitat	▪ Unsuitable seasonal location of low salinity habitat ▪ Reduced shallow-water subtidal/intertidal habitat ▪ Seasonal reduction in habitat volume by unsuitable water temperature (elevated), DO, turbidity (low), or salinity conditions)	0	0	X	0	▪ Reduce channel velocity ▪ Increase flood plain habitat ▪ Levee set-backs ▪ Flooded islands [**Note:** if salinity conditions are limiting, then flow-related actions would apply]
2-4	Reduced seasonal availability of adult habitat	▪ Unsuitable seasonal location of low salinity habitat ▪ Reduced shallow-water subtidal/intertidal habitat ▪ Seasonal reduction in habitat volume by unsuitable water temperature (elevated), DO, turbidity (low), or salinity conditions	0	0	0	X	▪ Reduce channel velocity ▪ Increase flood plain habitat ▪ Levee set-backs [**Note:** if salinity conditions are limiting, then flow-related actions would apply]

[9] Effects of disease on each of the life stages are not known.
[10] Not known if life stage is affected by this stressor, but effects are likely limited.
[11] It is not known if spawning conditions are a factor limiting smelt.

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Conservation Theme	Stressor	Impact Mechanism	Pelagic Fish				Potential Conservation Measures
			Egg	Larvae	Juvenile	Adult	
2-5	Sublethal exposure to toxics	Increased vulnerability to disease Reduced growth rates Increased vulnerability to predation Reduced reproductive success	?[4]	X	X	X	▪ Source control ▪ Point-source reduction ▪ Non-point source reduction ▪ Sediment removal/capping/avoid resuspension ▪ TMDL ▪ Increased enforcement
2-6	Competition	Reduced food supplies for native species Increased energy expenditure Potential displacement from suitable habitat	0	X	X	X	▪ Non-native competitor species management/control ▪ Reduce/avoid future introductions ▪ Improve habitat for native species ▪ Reduce habitat for non-native species
2-7	Water quality problems (reduced DO, seasonal salinity gradients, suspended sediments)	Impediment/barrier to habitat	?[4]	X	X	X[12]	▪ Reduce/eliminate/control BOD loading leading to low DO ▪ Increase flushing flows ▪ Erosion control ▪ Storm water pre-treatment ▪ Modify seasonal salinity control
2-8	Levee construction/island reclamation	Surface area/volume of suitable habitat reduced	X	X	X	X	▪ Levee set back ▪ Island flooding
Theme 3. Increase Habitat Quality And Availability[13]							
3-1	Reduced sediment input (change in volume, quality, geomorphic processes)	Changes in sediment grain size, sediment erosion within estuary, reduced dynamics of physical process	?[14]	?[14]	?[14]	?[14]	▪ Increase range of flow variation ▪ Reduce levee armor (in-Delta, upstream of Delta) ▪ Allow channel meander

[12] Seasonal aspects of this stressor may be same as 2-4.
[13] Important unknown: what constitutes habitat for pelagic species and the response of pelagic species to establishment of new habitat is unclear.
[14] The possible effects of this stressor on smelt is not known, however, because sediment inputs are a fundamental ecological process, there is likely a linkage to conditions that support smelt habitat.

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			Egg	Larvae	Juvenile	Adult	
3-2	Reclamation/conversion of wetlands	Reduction in the surface area and volume of aquatic habitat Reduction in organic production within estuary Reduction in water quality polishing	?[4]	X	X	X	▪ Levee set backs ▪ Flood islands ▪ Increased treatment of wastewater/storm water ▪ Increase tidally inundated wetlands
3-3	Land use changes (agriculture/urban development)	▪ Increased wastewater discharges (baseline and stormwater flows) ▪ Increased infrastructure and hard points	?[4]	X	X	X	▪ Increase requirements for discharge water quality parameters that adversely affect pelagic fish ▪ Pre-treatment for stormwater discharges ▪ Increased enforcement ▪ Reduce amount of urban development ▪ Exclude development from flood plains ▪ Reduce amount of industrial development ▪ Reduce amount of agricultural development ▪ Limit the geographic area of development
3-4	Reduced seasonal transport flows	Reduced downstream transport and distribution of eggs and larvae, seasonal co-occurrence of larvae, habitat, food supplies	0	?[15]	?[15]	?[15]	▪ Increase seasonal Delta inflow from Sacramento and/or San Joaquin Rivers ▪ Increase seasonal Delta outflow
3-5	Reduced upstream attraction flows	Delays in upstream migration, reduced flushing flows, false attraction/increased straying	0	0	0	?[16]	▪ Increase seasonal Delta inflow from Sacramento and/or San Joaquin Rivers ▪ Increase seasonal Delta outflow ▪ Increase variability, timing, magnitude, of flow
3-6	Reduced riparian vegetation	Reduced overhead cover Reduces organic/energy inputs to the aquatic system	0	0	?[4]	?[4]	▪ Conservation actions under Conservation Theme 6 apply

[15] It is unclear if this stressor affects smelt, however, it is known to be important for Chinook salmon and stripped bass.
[16] It is unclear if upstream flow conditions are a trigger for smelt migration.

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Conservation Theme	Stressor	Impact Mechanism	Pelagic Fish				Potential Conservation Measures
			Egg	Larvae	Juvenile	Adult	
3-7	Channelized riprap levees	Increased water velocities, reduced shallow water habitat, reduced cover, increased vulnerability to predation	0	X	X	X	▪ Reduce exports in localized areas ▪ Relocate intake ▪ Remove existing levee armoring ▪ Reduce/avoid future riprap ▪ Employ bioengineering techniques for levee protection ▪ Levee set-backs
3-8	Expansion of non-native species (Egeria, etc.)	Reduced habitat quality and increased vulnerability to non-native predators	0	X	X	X	▪ Expanded eradication/control program ▪ Reduce/avoid future introductions
3-9	Increased water depth (channel dredging; marinas, ship channels)	Reduced habitat suitability, increased velocity, reduced photic zone	?[4]	0	X	X	▪ Reduce dredging volume ▪ Reduce dredging locations ▪ Beneficial re-use of all dredge material for estuarine habitat ▪ Restore shallow-water habitats
3-10	Island subsidence (future under failed levee conditions)	Flooded islands may be to deep for suitable aquatic habitat Increased risk of levee failure and adverse effects on entrainment onto island, salinity distribution, etc.	0	?[4]	X	?[4]	▪ Reduce practices leading to subsidence ▪ Increase sediment accretion using dredge sediment re-use, import sediment, import agricultural waste. Increase organic production through agriculture/wetland management (re-build peat)
3-11	Increases in temperature (global warming)	Increased seasonal water temperatures	?[4]	?[4]	X	?[4]	▪ Restore wide belts of riparian vegetation adjacent to channels(?)
3-12	Changes in seasonal hydrology (climate change—diminishing snow pack, shift in rain cycle)	Change in the seasonal timing/magnitude of flows	?[4]	X	X	?[4]	▪ Modify reservoir storage and release

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3-13	Sea level raise	▪ Increased water depth and further loss of shallow-water habitat ▪ Change in flows and salinity (i.e., salinity moves upstream) ▪ Increased flow velocities	0	0	0	0	▪ Reduce rate of subsidence ▪ Promote active sediment accretion ▪ Restore habitat upstream ▪ Rebuild peat
Theme 4. Increase Habitat Diversity[12]							
4-1	Levees/reclamation	Loss of access to suitable habitat	?[4]	?[4]	X	X	▪ Remove levees ▪ Levee set-back ▪ Passage facilities ▪ Increase flood plain
4-2	Levees/reclamation	Loss of shallow water subtidal habitat	?[4]	?[4]	X	X	▪ Levee set-back ▪ Flood islands
4-3	Levees/reclamation	Loss of flood plain inundation	0	X	X	X	▪ Levee set-back ▪ Breach channel margin levees ▪ Flood shallow islands
4-4	Levees/reclamation	Loss of intertidal habitat	0	0	?[4]	?[4]	▪ Levee set-back ▪ Breach channel margin levees ▪ Flood shallow islands
4-5	Levees/reclamation/land use changes	Loss of riparian habitat	0	0	?[4]	?[4]	▪ Bioengineering for levee protection ▪ Plant riparian vegetation ▪ Avoid vegetation removal
4-6	Salinity control/compliance	Reduced salinity variability	0	?[4]	X	X	▪ Remove/relax existing salinity control requirements ▪ Modify seasonal inflow for greater salinity variation ▪ Modify season Delta outflow for greater salinity variation

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	Upstream impoundment storage and instream flow releases Flood control operations	Reduced hydrologic variability	0	X	X	X	▪ Modify seasonal inflow for greater hydrologic variation ▪ Modify season Delta outflow for greater hydrologic variation (add habitats that currently don't have—intertidal wetlands in the Delta and natural hydraulics in the Detla—flow directions seaward and tidal)
Theme 5. Increase Species Resilience							
5-1	Reduced genetic integrity and diversity[17]	Small spawning population Hatchery production[18]	?[4]	?[4]	?[4]	?[4]	▪ Reduce/avoid hatchery production ▪ Manage hatchery production for genetic integrity ▪ Increase habitat (See theme 3); Increase smelt pops ▪ Increase food production (See theme 6) ▪ Reduce mortality (See theme 1)
5-2	Reduced population abundance	Reduced genetic diversity Reduced population resilience	X	X	X	X	▪ Increase habitat (See theme 3) ▪ Increase food production (See theme 6) ▪ Reduce mortality (See theme 1)
5-3	Reduced population geographic distribution	▪ Reduced genetic diversity ▪ Increased vulnerability to impacts	?[4]	X	X	X	▪ Expand distribution of suitable habitat
5-4	Reduction in independent populations	▪ Reduction in genetic diversity ▪ Increased vulnerability to impacts and environmental extremes	?[4]	?[4]	?[4]	X	▪ Expand distribution of suitable habitat
5-5	Increased habitat stability[19]	▪ Reduced adaptation ▪ Reduced genetic diversity ▪ Increased vulnerability to impacts and environmental extremes	0	?[4]	X	X	▪ Increase seasonal variation in flows ▪ Increase seasonal variation in salinity

[17] To address this stressor, the minimum number of fish and distribution that needs to be maintained to provide for genetic integrity needs to be determined.
[18] This is not currently an impact mechanism for smelt, but could become an issue if it becomes necessary to sustain populations through hatchery production.
[19] Species are currently insulated from the historical range of perturbations because of the constrained Delta system. Restoration of the historical range of drought-flood conditions would eliminate habitat for exotics that benefit from Delta stability. An uncertainty is whether or not smelt have lost the ability to adapt to restored variability and whether or not restored variable conditions will favor other non-native predator/competitor species.

Conservation Theme	Stressor	Impact Mechanism	Pelagic Fish				Potential Conservation Measures
			Egg	Larvae	Juvenile	Adult	
5-6	Reduced habitat diversity	▪ Reduced adaptation ▪ Reduced genetic diversity ▪ Increased vulnerability to impacts and environmental extremes	?[4]	?[4]	?[4]	?[4]	▪ See Theme 3
5-7	Reduced frequency of chaotic events	▪ Reduced adaptation ▪ Reduced genetic diversity ▪ Increased vulnerability to impacts and environmental extremes	?[4]	X	X	X	▪ Increase range of seasonal variation in Delta inflow, outflow, and salinity intrusion
Theme 6. Increase Food Availability (phytoplankton, zooplankton, macroinvertebrates, forage fish, etc) **Note:** This conservation theme will be addressed at the March 16, 2007 BDCP Technical Working Session.							

Citations

Citations and other documentation to support the information provided in this table will be identified and provided in or appended to this table.